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INVESTIGATION OF THE INTENSITY OF CHARGED PARTICLES DURING THE FLIGHTS OF THE SECOND AND THIRD SPACESHIPS-SATELLITES

by V. L. Ginzburg, L. V. Kurnosova, V. I. Logachev,
L. A. Razorenov, I. A. Sirotkin, and M. I. Fradkin

[redacted]

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INVESTIGATION OF THE INTENSITY OF CHARGED PARTICLES DURING THE FLIGHTS OF THE SECOND AND THIRD SPACESHIPS-SATELLITES

(Issledovaniya intensivnosti zaryazhennykh chastits vo vremya poletov 2-go i 3-go korabley-sputnikov)

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by V. L. Ginzburg,
L. V. Kurnosova,
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The flux of charged particles was registered in the 187-339 km altitude range during the flights within the -65 to $+65^{\circ}$ latitude interval of the second and third spaceships.

A telescope from two series of gas-discharge counters, which was part of the apparatus utilized for measurement of fluxes of cosmic ray nuclei, served here as the registering device.

The telescope (represented in Fig. 1, next page) had a geometrical factor $\Gamma \approx 2.5 \cdot 10^{-4}$ m^2 ster. for the isotropic radiation originating from the half-sphere. The resolving time of the double coincidence circuit into which both series of counters were switched, was $\tau = 2 \cdot 10^{-5}$ sec. The charged particle intensity and their dependence upon the latitude was measured by the above-described scheme.

The number of telescope readings at various latitudes of the

Northern hemisphere during the flight of the 2nd and 3rd spaceships, is compiled in the following Table.

T A B L E

Geom. lat.	2nd spaceship		3rd spaceship	
	Count. rate N_{ct} pulse sec^{-1}	Global intensity J_{gl} part $cm^{-2} s^{-1}$	Counting rate N_{ct} pulse sec^{-1}	Global intensity J_{gl} part cm^{-2} s^{-1}
0°	0,83±0,03	1,36±0,03	0,72±0,05	1,32±0,06
10	0,93±0,06	1,57±0,06	0,75±0,07	1,32±0,09
20	1,0±0,1	1,7±0,1	0,76±0,06	1,32±0,07
30	1,3±0,1	2,0±0,1	1,1±0,1	1,8±0,1
40	1,9±0,2	2,6±0,2	1,6±0,4	2,4±0,4
50	2,5±0,2	3,1±0,2	2,0±0,1	2,7±0,1
60	2,6±0,1	3,3±0,1	2,2±,04	2,9±0,3
70	2,0	2,7	1,9±0,1	2,6±0,1

This Table indicates the global intensity obtained from the number of telescope readings except for random coincidences. The latter constitute 25% of the total at the geomagnetic equator. At 60° latitude, random coincidences constitute up to 50% of the total. At the same time, the estimate of random coincidences is made in the assumption that they caused only by particles capable to get through the telescope.*) The global intensity of primary cosmic rays is equal to 0.2 and 1 part. $\cdot cm^{-2} \cdot s^{-1}$ at the equator and in the region of high latitudes, respectively. Thus, the registered intensity by the device during both flights at all latitudes resulted several times greater than the intensity of cosmic rays

registered in the stratosphere and in the open space beyond the limits of the Earth's magnetic field. This difference is particularly noted in the region of the geomagnetic equator where the measured intensity exceeded by six times the intensity of cosmic ray particles. (The question as to whether there is really question of rise in the number of particles passing through the telescope, will be discussed below).

Several regional anomalies have been revealed in the radiation intensity [1, 2]. They were apparently related to the anomalies of the Earth's magnetic field.

Detailed graphic representations of the intensity as a function of time, and consequently of geographic coordinates and spaceshup's altitude, have been plotted for both flights, along their total paths. At the same time, data on intensity have been averaged for such time intervals, that the statistical error was not to exceed 5 to 10 percent of the intensity (for greater values of intensity, and its fast variation, the averaging interval was of 10 seconds and less). The examples of graphs for portions of spaceships' trajectories passing through intensity anomalies, are shown in Fig. 2(2nd spaceship), and Fig. 3 (3rd spaceship). On the basis of such type of graphs, maps of radiation intensity distribution over the terrestrial surface were drawn (Fig. 4 and 5). The lines of equal intensity, traced in the map, link the points of the trajectory with the same number of telescope readings. The numbers indicate at every line the number of telescope readings for 1 second.

It should be noted, that during spaceship's repeated flight over the same geographical point, and nearly at the same altitude, the registered intensity sometimes resulted somewhat different from that

registered during the preceding flight. In certain cases, the values of intensity differed almost twofold. The differences in the registered intensity during subsequent flights were particularly notable at higher latitudes. When drawing maps, brought forth in Fig. 4, 5, the greatest of all registered values was selected for each geographic point for its respective intensity. An example of discrepancies between the lines of equal intensity obtained on the basis of various flight of the spaceship over the same territory, is brought out in Fig. 6. Solid lines unite points of equal intensity obtained during earlier convolutions of spaceship's trajectory, and dotted lines — those of subsequent convolutions. Inasmuch as the device's orientation relatively to the lines of force of the terrestrial field has been varying, it is not possible to assert that some of telescope reading number's variations, noted in certain cases, reflect the variations in time of intensity of the radiation itself during subsequent flights.

The lines of equal intensity in Fig. 4 in the region of the South Atlantic and Southern anomalies make the data brought out in [2] somewhat more precise. Both anomalies are sharply delimited by the region of lesser intensity. The greatest number of telescope readings registered in the region of the Southern anomaly reached 60 sec^{-1}, and in the South Atlantic anomaly — 70 sec^{-1}. The general character of intensity distribution registered during the flight of the 3rd spaceship coincides with that obtained during the flight of the 2nd spaceship: Everywhere the intensity substantially exceeds that of cosmic ray particle flux, while in the Southern hemisphere, great anomalies in intensity are being observed (in the region of Southern anomaly, the intensity exceeds

300 to 400 times that of adjacent regions).

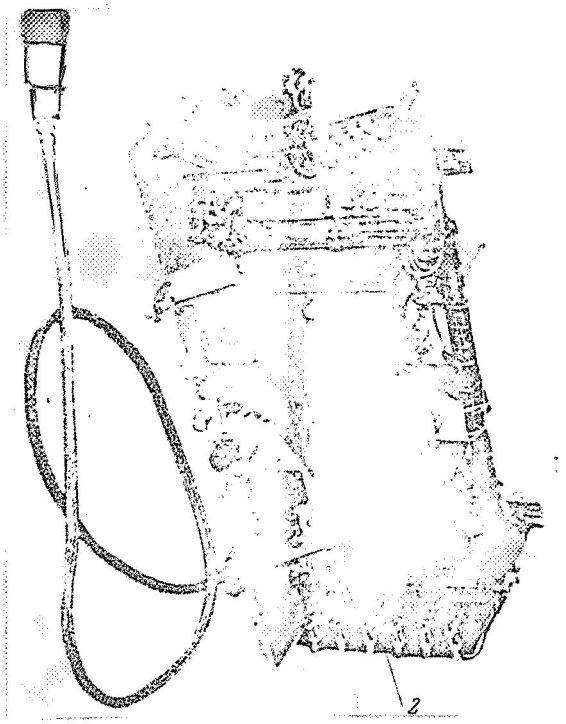


Fig. 1. Outside view of the telescope for the registration of cosmic rays:

1 — upper group of counters (Five STS-5 counters)
2 — lower group of counters (Eight STS-2 counters).

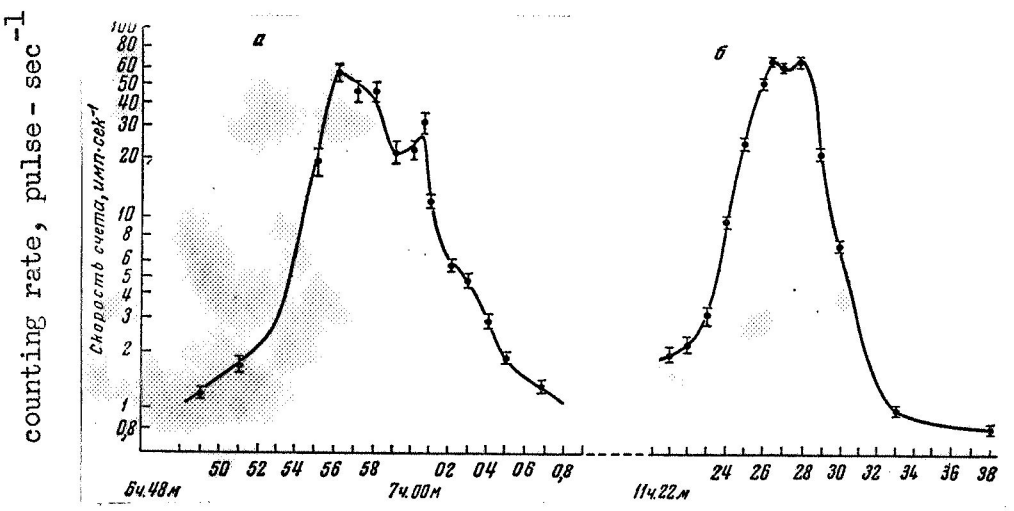
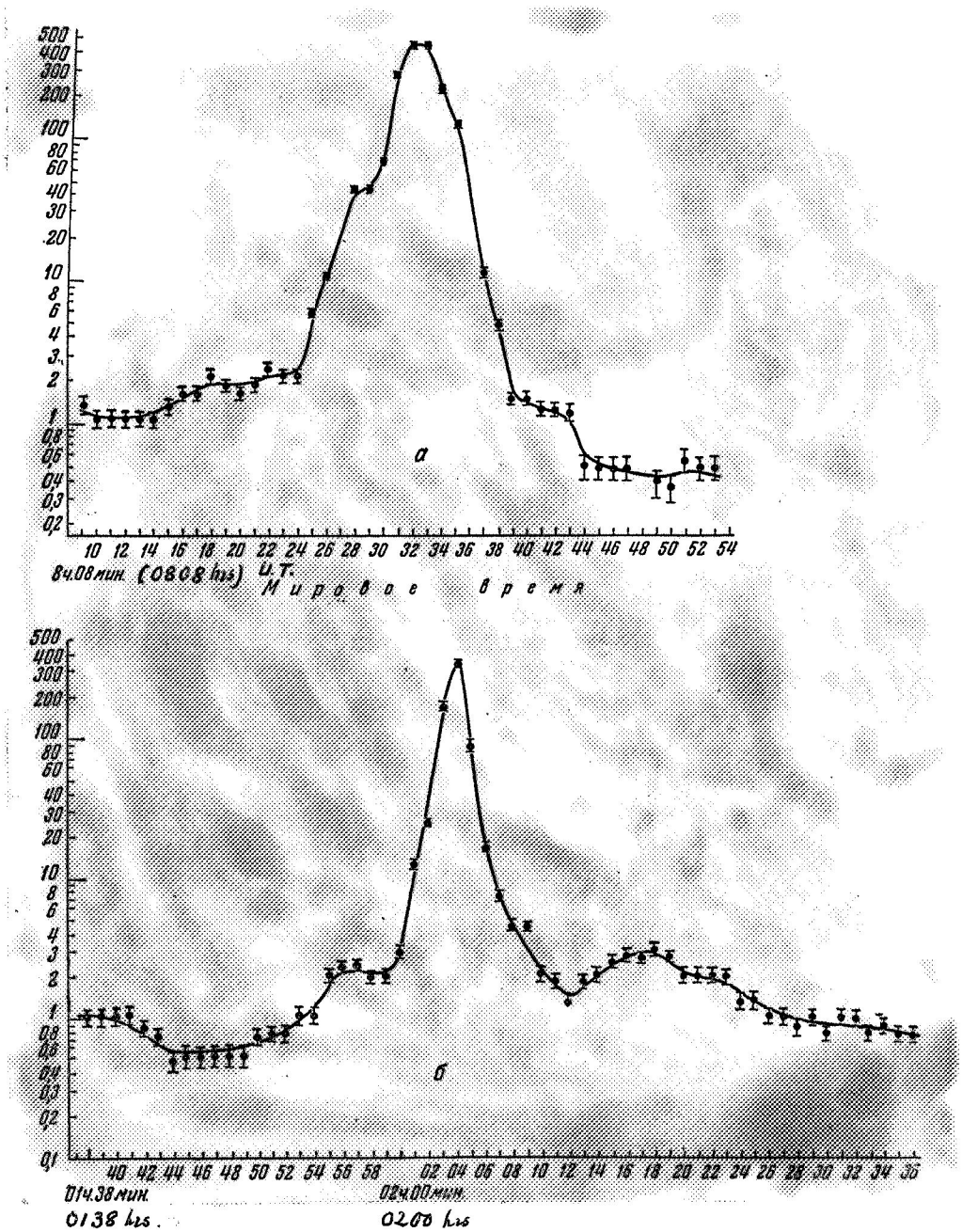


Fig. 2. Variation of the telescope's counting rate in time, in the regions of the Southern (a) and South Atlantic (б) anomalies, according to measurements on the second spaceship.

Universal Time.



Universal Time

Fig. 3. Variation in the counting rate of the telescope during two fiights of the 3rd spaceship through the region of the Southern anomaly.
a - 1 Dec. 1960; — 2 Dec. 1960. The counting rate is in ordinate axis and is expressed in pulse . sec $^{-1}$

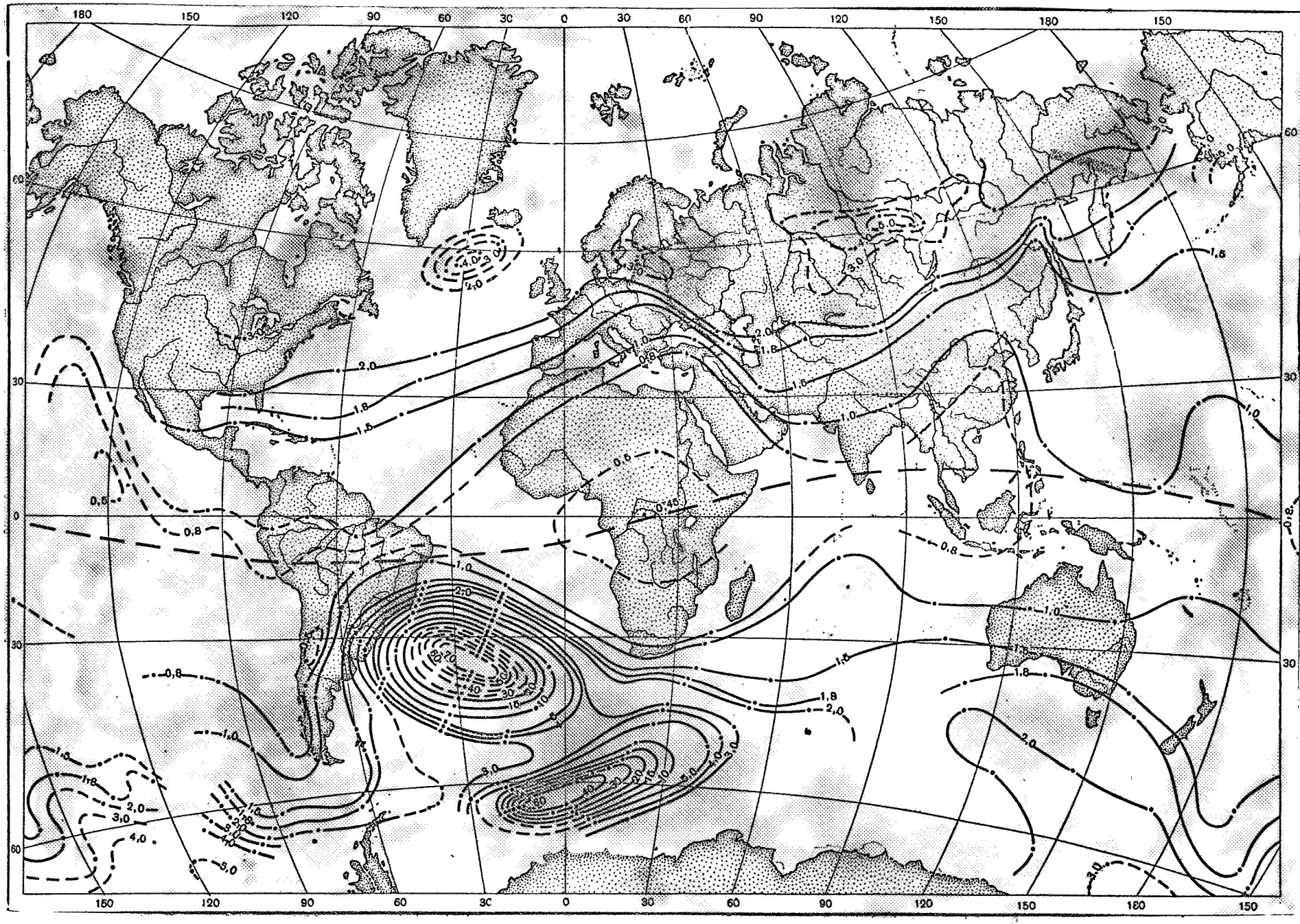


Fig.4. Distribution along the terrestrial globe of the lines of equal count rate for the telescope of the 2nd spaceship-satellite.

(Other captions are presented in A pendix)

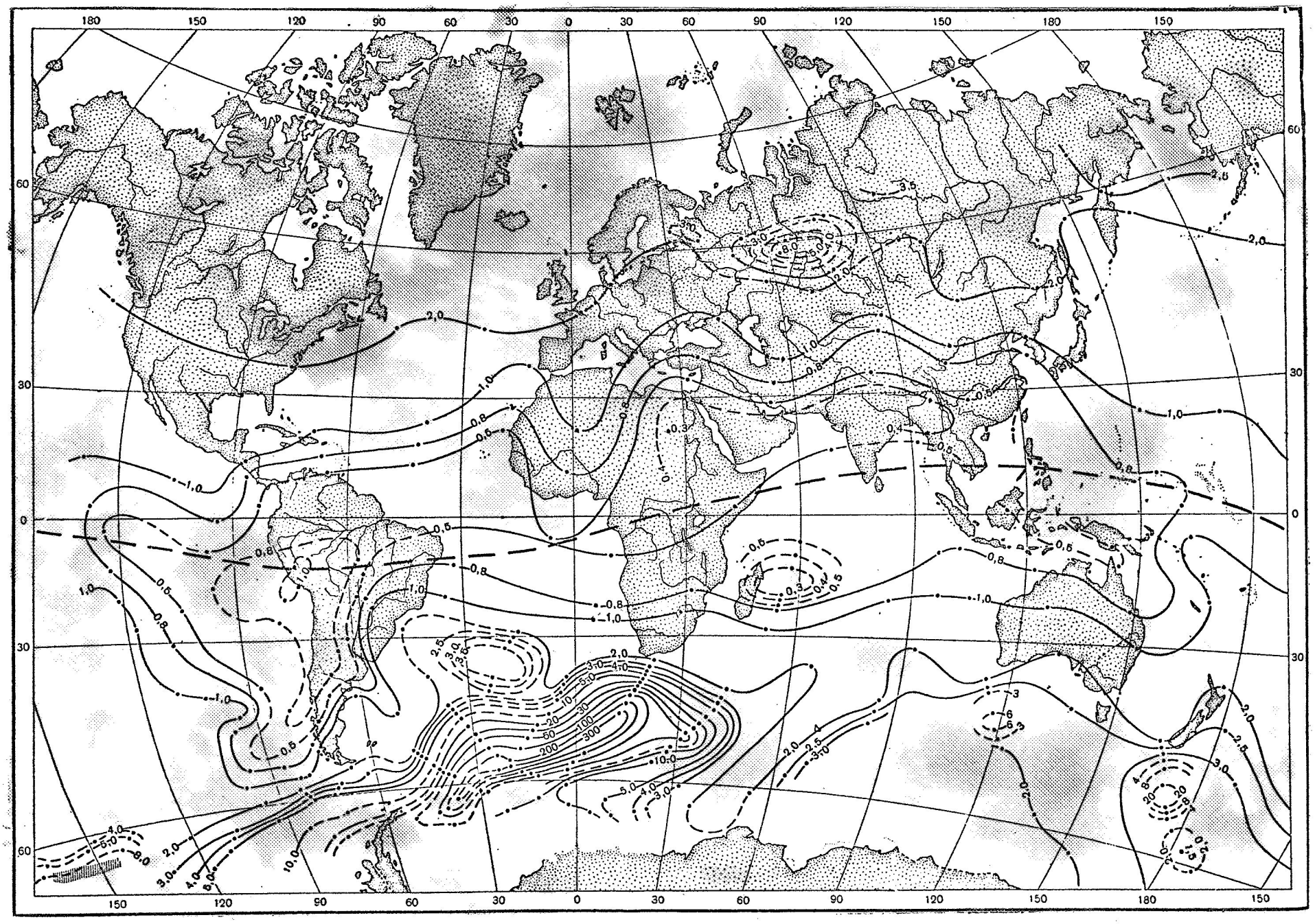


Fig. 5. Distribution along the terrestrial globe of the lines of equal counting rate of the 3rd spaceship's telescope.
(For other captions see appendix).

The intensity distributions in the region of anomalies, registered in the 306-339 and 187 - 265 km altitude ranges during the two flights, differ from one another. It appeared, that during the flight of the 3rd spaceship, the South Atlantic anomaly was weakly expressed, while the Southern anomaly was displaced toward the region of lower latitudes. Apparently, the South Atlantic anomaly constitues an "arm" of the inner radiation belt appearing as a consequence of magnetic field anomaly. Inasmuch as the inner belt is a stable formation, the weakening of intensity in the region of the South Atlantic anomaly during the flight of the 3rd spaceship in comparison with the data of the 2nd spaceship-satellite, should apparently be explained by altitude difference of both flights. The second spaceship passed the region of the South Atlantic anomaly at about 330 km altitude, while the 2nd flew at about 235 km, so that the difference in altitude was about 100 km. Apparently, the trajectory of the 3rd spaceship passed below the position of the inner belt's arm.

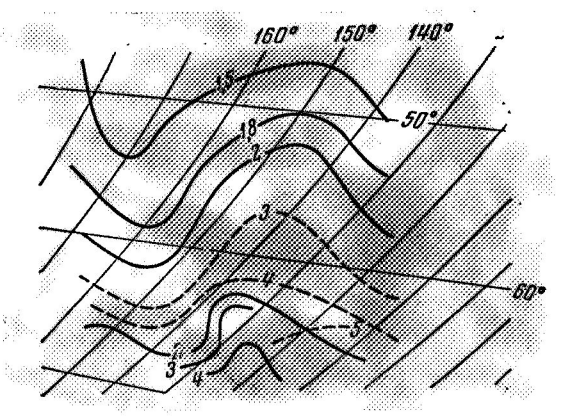


Fig. 6. Portion of the map of the Earth with lines of equal intensity obtained according to measurement data on various flights of the 2nd spaceship.

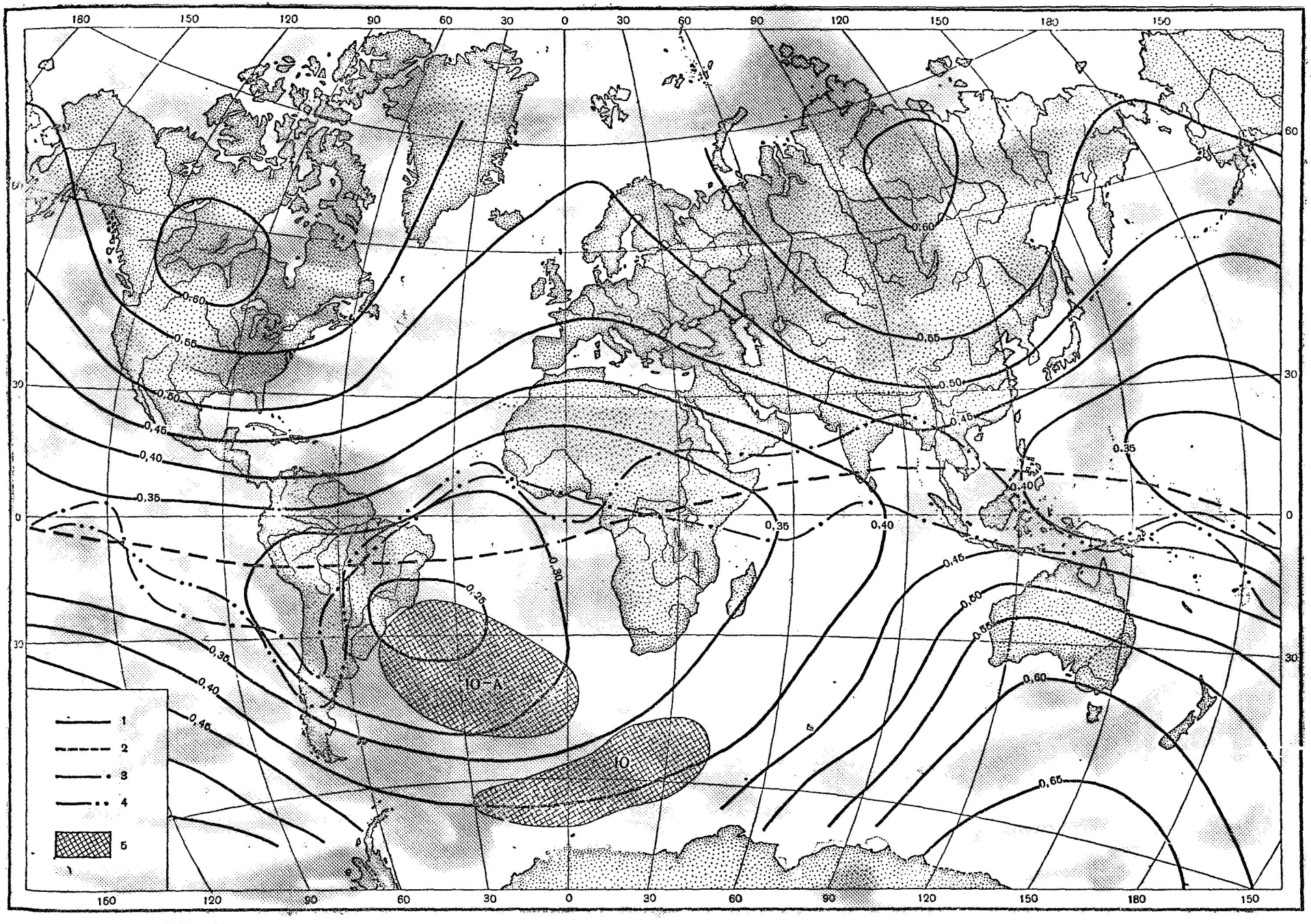


Fig. 7. Map of magnetic field intensity distribution at the Earth's surface (total vector). Annotated are the regions of the Southern and South-Atlantic anomalies (IO) and (IO-A) (see Appendix for other captions.

The relationship of the structure anomalies in radiation belts with those of the Earth's magnetic field is obvious. It was not however possible to assume that the regional anomaly of the magnetic field at the terrestrial surface exerts a substantial influence on the flux of charged particles to the 200 - 300 km altitude range. Fig.7 brings forth a map of isolines corresponding to the absolute value of magnetic field intensity on the terrestrial surface for the 1950 epoch, which was obtained with the help of maritime maps for the vertical and horizontal components of the field. The approximate position of radiation intensity in the South Atlantic and Southern anomalies is also indicated on that map. The close disposition of the region of the negative magnetic anomaly points to their relationship. The possibility is not excluded that the lines of force of the magnetic field at altitudes of the order of 300 km are distorted in such a way, that the "arm" of the inner radiation belt, representing the South Atlantic anomaly, connects with the "arm" responding to the Southern anomaly at altitudes exceeding 340 km.

The large number of radiation intensity anomalies in the southern and northern polar regions, their disposition and their variations' character, compel us to interpret these anomalies as being the edges of the Earth's outer radiation belt.

The presence of gigantic anomalies in the Southern hemisphere interfers with the investigation of latitude effect; thus, data of the Northern hemisphere were utilized to that effect. Plotted are in Fig.8 graphs of latitude dependence obtained for the Northern hemisphere on

the basis of measurements carried out on the 2nd and 3rd spaceships*). Attention is drawn by the fact that at high latitudes the increase in intensity ceases.

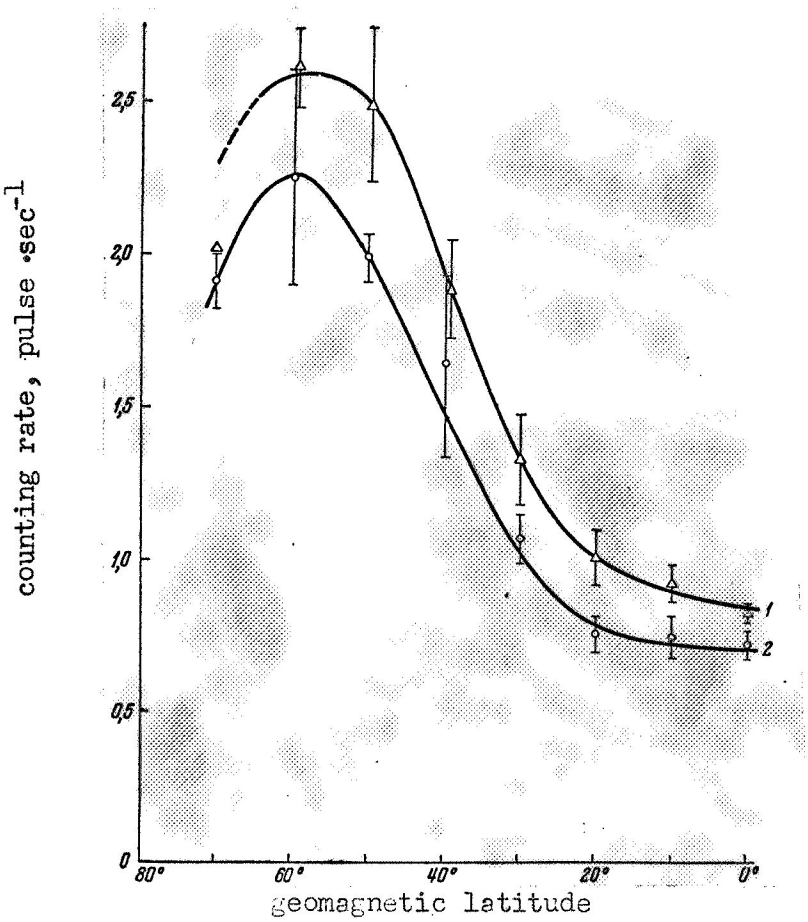


Fig. 8. Telescope's counting rate as a function of the geomagnetic latitude.

1 — according to data of the 2nd spaceship;
2 — " " " 3rd " .

*) At time of graph construction the portion of the "Northern anomaly" registered during the flight of the 2nd spaceship was excluded for one convolution, for it had a temporary character [1, 2]. This anomaly apparently appeared on account of a powerful charged particle flux inflow on the Earth, which originated in the Sun. The diagram of intensity as a function of time obtained in the region of the "Northern anomaly", is plotted in Fig. 9.

In this respect, the curve representing the course of the registered intensity ressembles that of latitude dependence of cosmic ray intensity. However, this similarity apparently is purely external, and the registered charged particle flux, many times exceeding that of cosmic rays, is of terrestrial origin. An approximate value of the intensity of charged particles was measured with the aid of a single gas-discharge counter at times of the same flights [3]. As may be seen from Fig. 8, the intensity, registered during the flight of the 3rd spaceship, was about 1.2 to 1.3 times lower than that registered by the 2nd spaceship. (This has no bearing on the anomaly region). The circumstance referred-to is possibly also linked with with a different mean flight altitude of the 2nd and 3rd spaceships. The second spaceship had an orbit near the circular, with a 306 km perigee, and 339 km apogee. The 3rd spaceship moved along an elliptical orbit with a 187 km perigee and 265 km apogee. Therefore, there was a 119 km difference in the perigee altitude of both spaceships. The telescope installed on the 3rd spaceship, was totally similar to that installed on the 2nd spaceship.
As to the installation's scaling circuit, it had a somewhat greater capacity, so that the measurements of intensity could be carried out in a much broader range — from unities through 10^5 telescope readings per minute.

Thus, the obtained data on the spatial distribution of radiation intensity give an idea about borderline effects of radiation belts at 200 - 300 km above ground, and outline a series of heretofore unnoted peculiarities. It must however be noted that borderline effects may somewhat vary in their appearance with time on account of instability of

radiation belts, and particularly of the outer belt (see ref.[4, 5]).

It must be particularly referred to temporary anomalies in intensity observed during the two flights. To them should be related the "Northern anomaly" resistered on 20 August 1960 at 07 40 hours UT, and also the anomaly registered during the flight of the 3rd spaceship in the southern polar region on 1 December at 14 22 hours UT. The number of readings in the maximum of intensity for these anomalies respectively reached 80 and 40 sec^{-1}. Both anomalies had a temporary character : they were only observed during one passing of the spaceship through the anomaly region, while during the preceding spaceship's passings through the region of anomalies, the intensity differed little from its mean value for the given geomagnetic latitude. These intensity increases are apparently related to the solar activity. They may be explained by the inflow on Earth of powerful charged particle fluxes directly from the Sun, [6], or by their temporary capturing in the magnetic traps.

The line of least radiation intensity ("radiation equator") may be determined for each of the flights. Generally speaking, it follows the geomagnetic equator, but in the Western hemisphere, it deflects significantly to the south for both the 187-265 km and the 306-339 km altitude ranges. The "radiation equator" is shown in Figure 7.

Certain conclusions may be made about the composition of the registered radiation. Since there was interposed between the two counter groups a plexiglass sheet 3 cm thick, which was serving as Čerenkov counter's detector for cosmic ray nucleus count, the telescope could register protons with a kinetic energy of not less than 60 MeV, and

electrons with energies of not less than 8 MeV. As pointed out at the beginning of the present paper, during the determinations of intensity, only random coincidences were excluded from particles, capable on account of their energy, to pass through the telescope. However, had there been a great quantity of particles with low energies, they would also be giving accidental (random) coincidences. Thus the compiled value of J_{gl} in the Table of page 2, has a somewhat conditional character. Let us admit that the count increase (by comparison with readings from primary cosmic rays) is explained by accidental coincidences conditioned by electrons with kinetic energies $E_e \gtrsim 2$ MeV (such electrons pass through the container's envelope and may be registered by telescope counters). Their global intensity at the equator must then be 2.7 electron $\cdot$ $cm^{-2} \cdot sec^{-1}$, i. e. exceeding 15 times the intensity of cosmic rays.

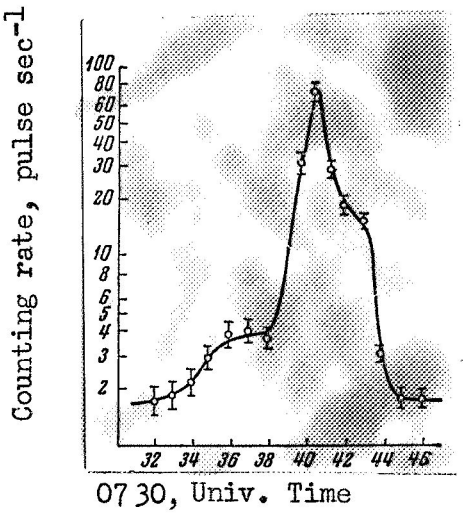


Fig. 9. Variation of telescope' counting rate in the region of the "Northern anomaly" according to 2nd spaceship measurements.

However these electrons cannot form as a result of decay of albedo neutrons with energies $E_n \leqslant 100$ MeV. It is more likely that the increase in the number of readings is linked with protons with $E_p > 60$ MeV. Obviously, no final respective conclusion can yet be made with a sufficient assurance, and as a whole, the question of the cause of the increase of telescope readings at 200 - 300 km altitudes still remains open. Nevertheless, we shall at this stage pause at the discussion of a certain model of

the inner radiation belt's lower part. At the same time, we shall begin with the assumption that the inner belt is formed of protons, and that it has very few electrons with energies higher than, say ~2 MeV.

As is well known, the inner radiation belt is clearly expressed at heights of the order of 1000 km, while the altitude at which a sharp increase in intensity is observed is dependent upon the magnetic longitude [7]. At the same time it has been already noted earlier [8, 9] that the intensity of charged particles notably exceeds that of primary cosmic rays even at substantially lower altitudes (of the order of 400 to 600 km). The above-presented data show that this region extends at least to 200 km. At the same time, in equatorial regions, radiation flux practically does not depend on altitude, and it may be identified with the flux of primary cosmic rays [10]. Thus, the impression is created, that the dependence of radiation intensity on altitude may be represented in the form of a curve, schematically indicated in Fig. 10.

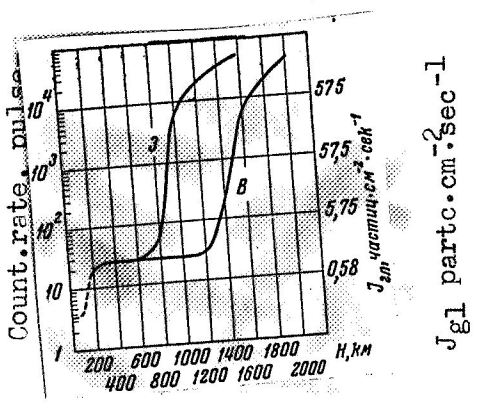


Fig. 10. Course of the charged particle intensity with distance from the ground Branches "З" and "В" refer to measurements in West and East.

The number of protons formed as a result of the decay of neutrons outflying from the terrestrial atmosphere, does not (in the first approximation, at short distances from the Earth) depend upon the altitude h. At the same time, the ionization losses suffered by charged particles, are proportional to atmosphere density $\rho(h)$. That is why, by taking them for the basic mechanism of the particle "outflow" from the radiation belt, we may

consider that the particle flux must be proportional to ρ^{-1}. Unfortunately, because of a substantial dispersion of data on atmosphere density and on global charged particle intensity J_{gl}, we are not in a position to make a quantitative comparison of theory with the observations according to the material available. Furthermore, if we take into account that ρ and J_{gl} depend on time and place of observation, we must, strictly speaking, use during the computations the values obtained simultaneously. With the view of a known orientation, let us take advantage, however, of the density values based upon a series of data

h, км	100	150	200	300	400	500	600	700	800	900	1000
ρ, $g \cdot cm^{-3}$	10^{-8}	10^{-11}	10^{-12}	10^{-13}	$2 \cdot 10^{-14}$	$2 \cdot 10^{-15}$	$6 \cdot 10^{-16}$	$2 \cdot 10^{-16}$	$6 \cdot 10^{-17}$	$3 \cdot 10^{-17}$	10^{-17}

At altitude decrease below 300 km, density ρ begins to rise sharply increasing by about two orders between 150 and 100 km, and by one order at passing from 300 to 200 km. Thus, if we consider that the observed flux increase is related to the contribution by trapped protons, it is clear, that below about 150 km, that increase must be unimportant. Indeed a tenfold decrease in intensity $J_{gl} \approx 1$ particle $\cdot$ cm^{-2} $\cdot$ sec^{-1}, measured at 200 km altitude, will obviously lead to a magnitude lower than the cosmic ray intensity, which in the region of the equator is about 0.2 particle $\cdot$ cm^{-2} $\cdot$ sec^{-1}. This conclusion agrees completely with the intensity ratio observed for that altitude range.

At sufficiently great heights (in connection with particle drift around the Earth), the intensity is determined by the density of the atmosphere at the altitude, at which the given particles are situated in the western hemisphere [7]. But beginning from a certain height h_{cr} and below,

the intensity will be basically dependent only upon the height above the Earth in the given region. It is obvious that h_{cr} is determined from the condition

$$t_{Д} \approx \frac{2\pi R}{v} \sim t_{ion} ,$$

$$v_{Д} \sim \frac{v_{\perp}^2}{\omega_H R} , \qquad \omega_H \approx \frac{eH}{Mc} ,$$

where $v_{Д}$ is the velocity of the drift around the Earth, $v_{\perp}$ is the projection of particle velocity $\underline{v}$ on a plane perpendicular to the direction of the magnetic field $\underline{H}$, $\underline{R}$ is the radius of the Earth and t_{ion} is the lifetime connected with ionization losses.

For protons with energy $E \gtrsim 60$ MeV, $v \approx 10$ cm $\cdot$ sec^{-1} and in equatorial latitudes at small heights $\omega_H \approx 2 \cdot 10^3$ sec^{-1}. Hence, at $v_{\perp} \approx 5 \cdot 10^9$ cm $\cdot$ sec^{-1} we have $v_{Д} \approx 2 \cdot 10^7$ cm $\cdot$ sec^{-1} and $t_{Д} \approx 200$ sec. Admitting a range $l \approx 4$ g $\cdot$ cm^{-2}, we shall obtain that the lifetime $t_{ion} = \frac{l}{\rho v}$ is equal to about 200 sec at $\rho \approx 2 \cdot 10^{-12}$ g $\cdot$ cm^{-3}, which which corresponds to the altitude (height) $h_{cr} \sim 200$ km. By virtue of line of force distortion, the ionization losses for particles at the equator are determined by the density at an altitude somewhat lower that that of the place of observation. Besides, protons with 60 — 100 MeV energies have in the magnetic field of the Earth at an altitude of the order of 200 km a curvature radius of the order of 25-50 km, and that is why they will be moving part of the time at lower (thus denser) atmosphere layers. Taking these circumstances into account and the roughness of the estimate carried out, it seems quite possible that the intensity

may already vary somewhat notably with longitude at 300 km altitude, and perhaps higher (in fact it is apparent that $h_{cr} \gtrsim 300$ km).*)

The density ρ varies from altitudes of the order of 400-500 km, to those of the order of 1000 km, by about three orders. In the Western hemisphere they correspond to the boundary of the intense inner radiation belt. That is why, in case of adhering to the law $J \sim \rho^{-1}$, the proton intensity from neutron decay must constitute at altitudes of the order of 1000 km about 10^3 particle $\cdot cm^{-2} \cdot sec^{-1}$. This figure seems reasonable from the viewpoint of the available data on the intensity of the inner radiation belt. (see ref. [7, 9]).

By virtue of the above-said, one may consider within the framework of incomplete data, that the general picture of the lower part of the inner radiation belt in the equatorial region may conform, for altitudes higher than the 400-600 km range, with a simplest model in which only ionization losses are accounted for. In passing to higher latitudes, the picture must become more complicated. It is necessary to make more precise for these regions, the composition, the spectrum and altitude course of charged particles. At altitudes below the 400 - 600 km range, substantial deflections from the law $J \sim \rho^{-1}$ are noted, if one bases himself on Figure 10. In particular, the above-referred to data attest only about a weak rise in intensity at passing from 200 to 300 km, in spite of an about tenfold decrease of the density ρ. Let us note in connection with this, that there exist well known foundations, that lead us to expect substantial departures from the dependence $J \sim \rho^{-1}$ at altitudes from 200 to 500 km. They stem from particle shifting

*) See Appendix

or diffusion across the magnetic field. At diffusion on account of collisions, the diffusion coefficient across a field of the order of

$$D_c \sim \frac{v^2 \nu}{\omega^2_H},$$

where ν is the number of collisions, and in the assumption $\omega^2_H \gg \nu^2$. For protons with 50 - 100 MeV energies, $\nu = 6 N_{air} v$, $6 \sim 5 \cdot 10^{-25}$ cm^2. N_{air} being the N and O nuclei' concentration in the atmosphere. For an altitude $h \sim 300$ km for example, $N_{air} \sim 10^{10}$ cm^{-3}, $D_c \sim 10^9$ and $\nu \sim 10^{-4} \cdot \sec^{-1}$.

The diffusive flux

$$j = - D(h) \cdot \frac{dN}{dh},$$

where N is the concentration of fast particles. That is why, for example, for a fixed flux j the gradient $\frac{dN}{dh}$ must sharply decrease in case of a sharp increase of D(h). The latter does take place exactly when at altitudes below 500 - 600 km, the density ρ begins to vary several times faster (see Table page 17). For a correct computation of the distribution by altitude of fast particles, the following equation ought to be resolved:

where A and [illegible] are respectively the number of particles forming at neutron decay, and vanishing as a result of ionization losses in the unit of time and per volume unit. It is not excluded that one cannot limit himself to the solution of a one-dimensional problem, and that the distortion of the lines of force must also be taken into account.

One must bear in mind that still another mechanism of diffusion exists, or, to make it more precise, a mechanism of particle displacement across the magnetic field. This mechanism is linked with the presence of electric fields E, inducing particle drift with a velocity

$$v_{Д} \sim \frac{cE}{H} .$$

In the F-layer of the ionosphere, the characteristics ionized gas flows are, as is well known

$$v_o \rightarrow 5 \cdot 10^4 \text{ cm} \cdot \text{sec}^{-1}$$

which correspond to fields $E \sim \frac{v_o}{c} H$, reaching 10^{-4} w $\cdot$ cm^{-1}. When such a field exists in the equatorial region and is directed horizontally, the fast particle will shift in it during the time $\underline{t}$ by a distance of the order of $3 \cdot 10^4$ t. Selecting the time $\underline{t}$ as being equal to about 30 sec., which still is small by comparison with the drift time around the Earth, $t_{Д} \sim 200$ sec, we shall obtain for dispacement across the the field, a value of the order of 10^6 cm. It is hardly possible to select a longer time $\underline{t}$, inasmuch as the field $\underline{E}$ cannot be oriented everywhere in the same direction. Thus the diffusion across the field, may result particularly significant from the point of view of "plateau" formation, particularly by virtue of collisions, and generally-speaking, from that of departures from the law $J \sim \rho^{-1}$ at 200 – 300 km altitudes. At the same time, this question cannot be considered by any means as finally resolved, and in the main, special measurements of a complex character are indispensable. Indeed, we must first of all be aware of the

dependence on the altitude, longitude, altitude, observation time and registered energy, of the intensity of the charged particles being identified. Secondly, data related to the time and place, on density $\rho(h)$ distribution must be available, and also all information contingent on the state of the ionosphere and of the Earth's magnetic field.

We shall present in conclusion, the estimate of the dose of radiation under a layer of matter of the order of $4\ g \cdot cm^{-2}$ at 200 - 300 km altitude. If one considers that in the equatorial zone the telescope registers basically protons with energies $E_p \gtrsim 60$ MeV, the dose of radiation obtained in that region during 24 hours will be about 30% of the ultimately admissible weekly dose. In the region of the South Atlantic anomaly, the power of the dose at 330 km altitude is by one order higher than at the equator.

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**** E N D ****

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on 8 February 1962.

ADDENDA and REFERENCES Follof ../..

A P P E N D I X

Infrapaginal notes *)

1) page 2.

For the finding of the global intensity J_{gl}, utilized was the relation

$$N_{count.} = \frac{J_{gl}}{2\pi} + 2\tau S_1 S_2 J^2_{gl},$$

where N_{count} is the number of telescope readings and S_1 and S_2 are the surfaces of the upper and lower group of counters.

2) page 19:

The height h_{cr} itself depends obviously on the intensity and the configuration of the magnetic field in the examined region. Thus at h h_{cr} the distinction between the heights of the lower "boundary" of the inner belt in the eastern and western hemispheres sharply disappears, and yet one cannot expect a total independence from the magnetic field

3) Fig.4 (Captions)

Dotted lines represent the lines of equal intensity drawn by the small number of points, or by points determined with a lesser reliability. The shaded line represents the geomagnetic equator. The region where a great temporary-character rise in intensity was observed ("Northern anomaly") is indicated by shadings.

4) Fig.5:

Same caption except that the shading indicates the region in the South Pacific where suxh temporary rise in intensity was observed.

5) Fig.7.

1 - isolines of the total vector; 2 — geomagnetic equator; 3, 4 *— - lines of minimum intensity ("radiation equator") according to measurements on the 2nd and 3rd spaceships-satellites. 5 - anomaly regions.

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